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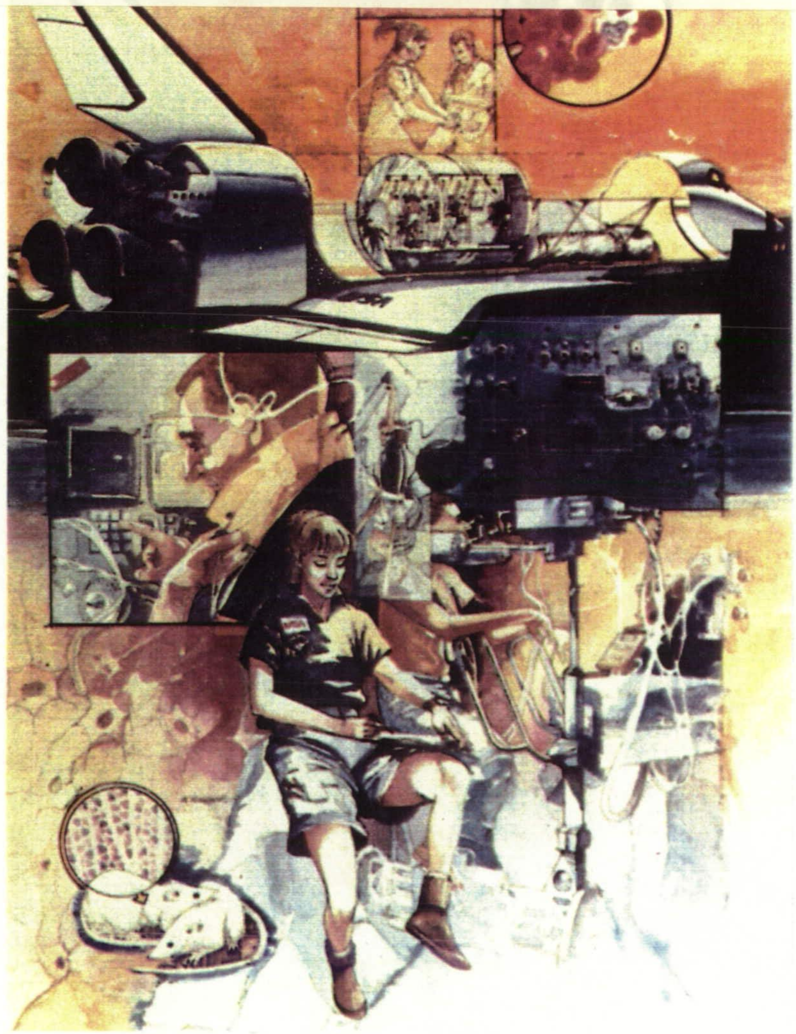

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Spacelab Life Sciences 1

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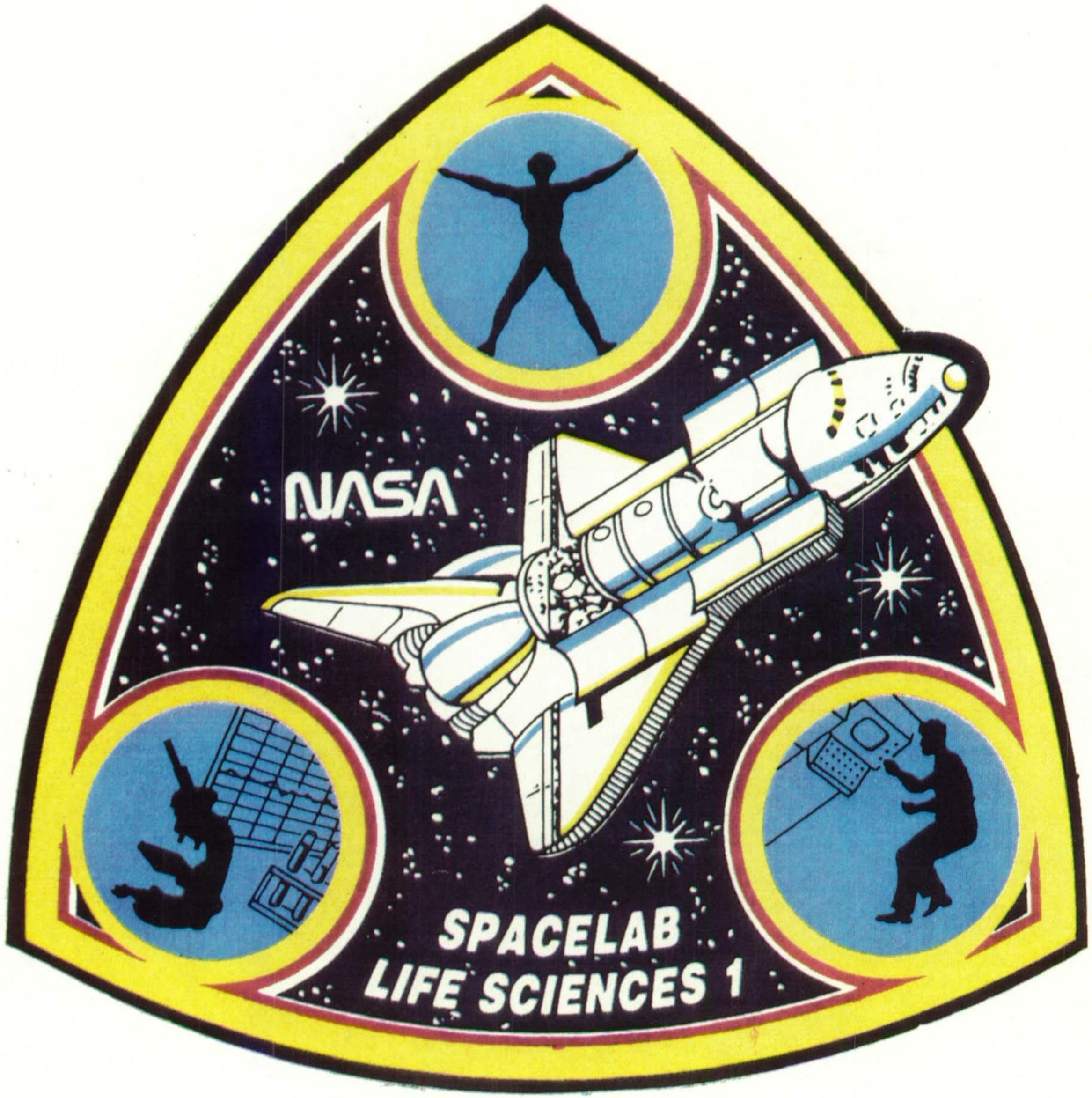


STS-40

Spacelab Life Sciences 1

1991

STS-40 Spacelab Life Sciences 1
(SLS-1)

The First Dedicated Spacelab Life Sciences Mission

May 1991

Life Sciences Division

Office of Space Science and Applications

National Aeronautics and Space Administration

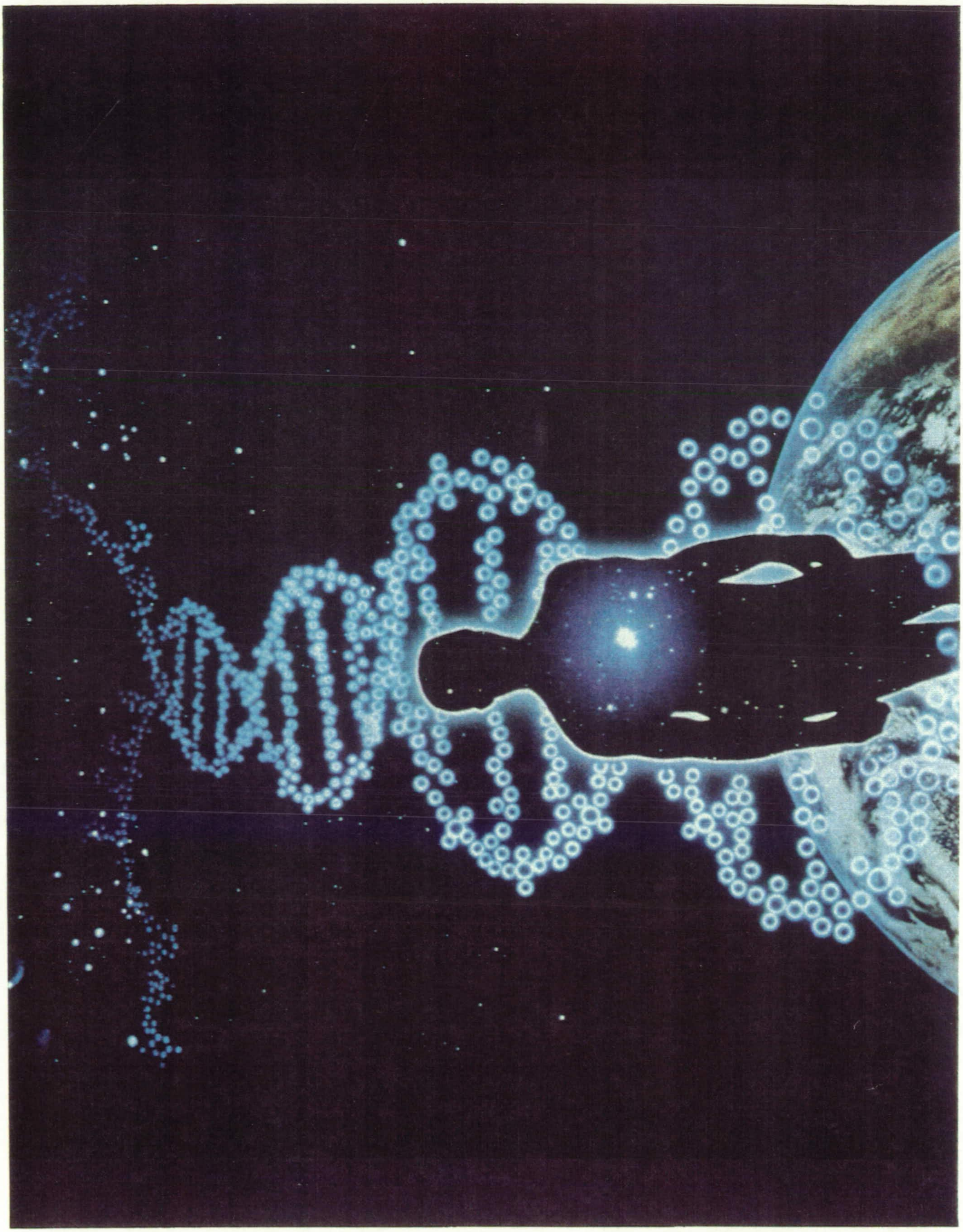
Contents

Spacelab Life Sciences 1 (SLS-1) Mission Objective

Successful exploration of space depends on the health and well-being of people who travel and work there. For this reason, the National Aeronautics and Space Administration (NASA) has dedicated several Space Shuttle missions to examine how living and working in space affects the human body. Spacelab Life Sciences 1 (SLS-1) is the first of these missions.

The main purpose of the SLS-1 mission is to study the mechanisms, magnitudes, and time courses of certain physiological changes that occur during space flight and to investigate the consequences of the body's adaptation to microgravity and readjustment to gravity upon return to Earth.

How does space flight influence the heart and circulatory system, metabolic processes, the muscles and bones, and the cells? If responses to weightlessness are undesirable, how can they be prevented or controlled? Will the human body maintain its physical and chemical equilibrium during months aboard a space station and years-long missions to Mars? When crews return to Earth, what can they expect to experience as their bodies readjust to Earth's gravity? With the SLS-1 experiments, NASA is addressing some of these questions.



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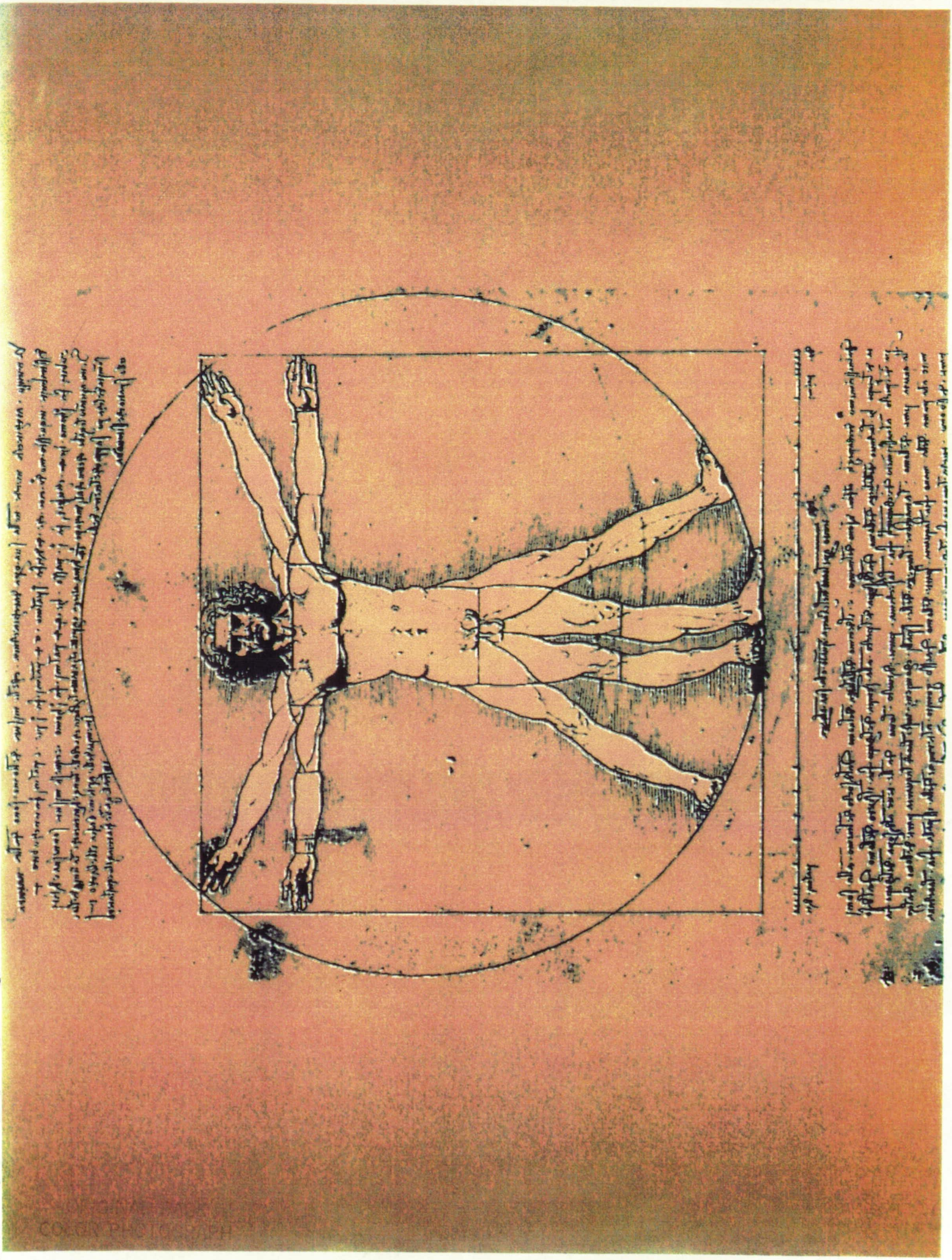
The Importance of SLS-1

Spacelab Life Sciences 1 (SLS-1) is the first Space Shuttle flight dedicated entirely to the life sciences. The suite of experiments on SLS-1 will investigate the consequences of the body's adaptation to the microgravity of space, and its readjustment to Earth's gravity following the flight into space.

The integrated set of science investigations aboard SLS-1 is designed to study the effects of space flight on the human body as a whole. Scientists will obtain a greater understanding of how the body adapts to space flight by carrying out a closely related set of investigations that examine the acute (early) effects of space flight on six interdependent body systems:

- **Cardiovascular/Cardiopulmonary System** (heart, lungs, and blood vessels)
- **Renal/Endocrine System** (kidneys and hormone-secreting organs)
- **Blood System** (blood plasma and white blood cells)
- **Immune System** (white blood cells)
- **Musculoskeletal System** (muscles and bones)
- **Neurovestibular System** (brain and nerves, eyes, and inner ear)

The SLS-1 mission provides investigators the first opportunity to study the acute effects of weightlessness—their mechanisms, time course, and magnitude—in a comprehensive, interrelated fashion using humans and animals. To follow the time course of adaptation, measurements will be taken at regular intervals and specific times before, during, and after flight. In addition, this will be the first Shuttle mission where physiological measurements are made so soon after launch—immediately after exposure to weightlessness. This data will help us understand the events that initiate the adaptive changes in the body that have been observed on other missions. Many physiological measurements will be made for the first time in space; others will build upon, and extend, the findings of previous missions and ground-based studies.



Space Life Sciences Research: An Historical Overview

Phase 1 (1960s)
Mercury, Gemini, Apollo

The first phase of U.S. space life sciences activities included the accomplishment of a very limited set of objectives during the Mercury, Gemini, and Apollo Programs. These programs represented the first opportunity for U.S. scientists to demonstrate that humans can indeed survive the rigors of space flight.

The Mercury Program (with flights up to 34 hours) provided the first indication that humans are able to withstand the stresses of launch and re-entry, as well as the physiological challenges associated with orbiting the Earth.

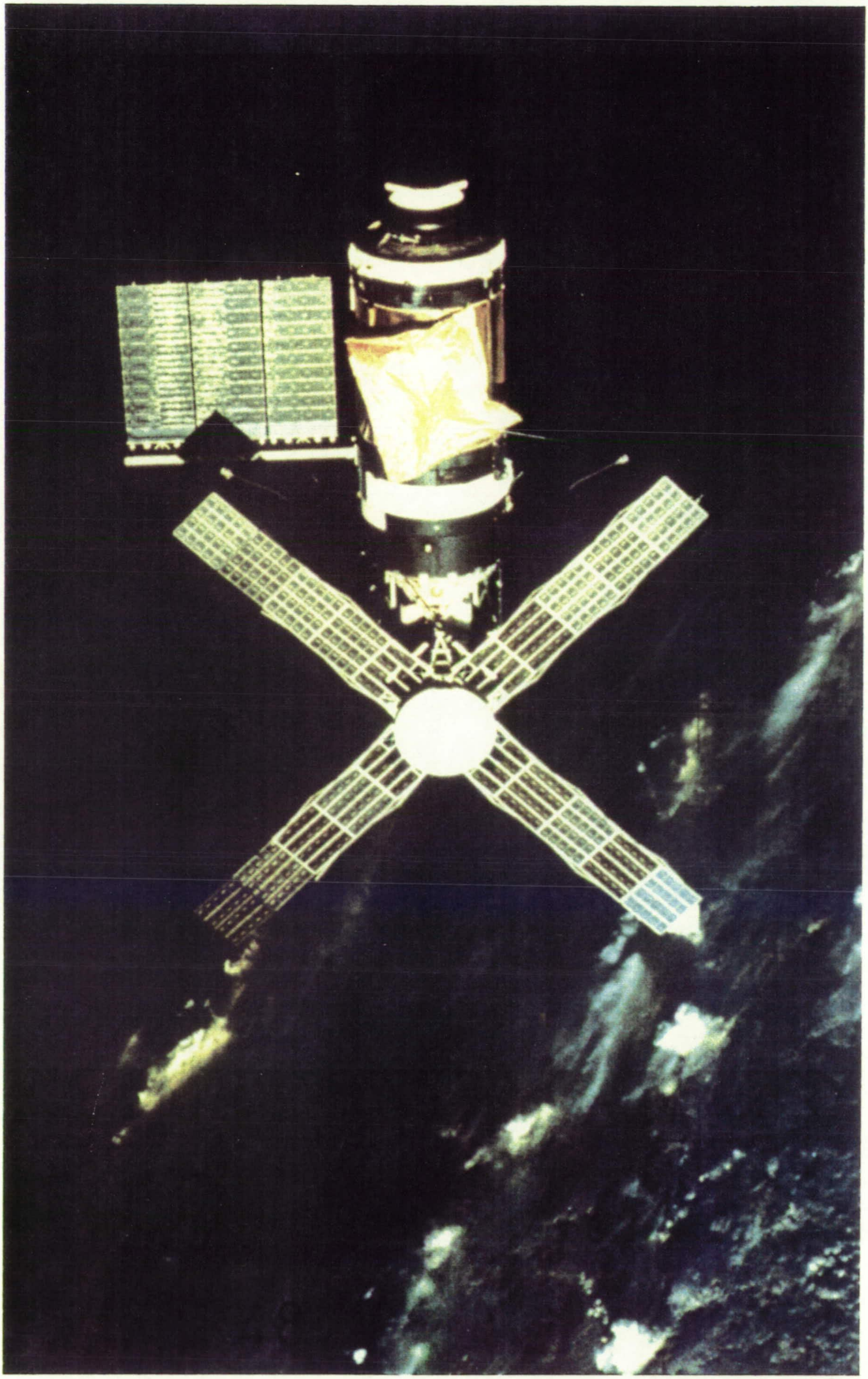
The Gemini Program (up to 14 days) helped to reinforce the conclusions of the Mercury Program and provided further confidence that not only could humans survive space flight, but that humans could function productively in space. The first Extra-Vehicular Activity (EVA) by a U.S. astronaut was performed successfully during the Gemini Program. These early activities helped to determine that human performance in the space environment was adequate for a lunar mission, and thus the U.S. Space Program embarked on the Apollo era.

The Apollo Program, which culminated in the first lunar landings, incorporated a broad-based biomedical support program to prevent in-flight illness and the possibility of Earth's contamination by lunar organisms, and to further study the effects of human exposure to the space environment.

Phase II (1970s)
Skylab

The second phase of U.S. space life sciences activities was meant to demonstrate that humans could adapt to and function effectively in space for extended periods of time.

Skylab, the first U.S. orbiting laboratory, provided the capability for extensive physiological testing and medical monitoring for missions lasting 28, 59, and 84 days. This program allowed the first comprehensive program of biomedical research in space over extended periods, to determine the time course of physiological changes in humans.



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Space Life Sciences: Now and Into the Future

Phase III (1980s & 1990s)
Shuttle/Spacelab

The third phase of U.S. space life sciences activities is currently in progress. This phase involves groups of focused, interrelated studies of human adaptation to space and is carried out aboard the U.S. Space Shuttle. The Shuttle is the first reusable space vehicle, unique in that it requires piloted reentry and landing. The Spacelab is an orbiting laboratory, flown on the Space Shuttle, which can be tailored to carry the necessary equipment for the accomplishment of a variety of science experiments. For life sciences, the Spacelab provides the opportunity to carry out biomedical research in a laboratory setting aimed at investigating the adaptation process that all humans experience while in space.

The SLS-1 Mission is one link in the chain of events that have been or will be carried out in pursuit of space life sciences research on the U.S. Shuttle/Spacelab. There have been limited opportunities for life sciences involvement on four previous Spacelab missions. **The SLS-1 Mission is the first dedicated life sciences Spacelab mission in the history of the NASA Shuttle program.** Future plans call for a second, third, and possibly fourth dedicated "sister" mission (SLS-2, SLS-3, and SLS-4, respectively) to be flown during the 1990s. In addition, life sciences involvement is planned for other Shuttle/Spacelab missions, along with international participation, that are now scheduled through the next 8 years. The duration of the Spacelab missions will grow from the current SLS-1 9-day mission up to what is referred to as an extended duration mission of 16 days.

Spacelab Missions with Life Sciences Payloads

Missions	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
SL-1 (9 days)	▲ Neurovestibular, Blood Studies, Space Biology															
SL-3 (7 days)			▲ Metabolic, Neurovestibular, Hardware Verification													
SL-2 (8 days)			▲ Musculoskeletal, Plant Biology													
SL-D1 (7 days)			▲ Cardiovascular, Neurovestibular, Space Biology, Plant Biology													
SLS-1* (9 days)									▲ Cardiovascular/Cardiopulmonary, Metabolic, Musculo-skeletal, Neurovestibular, Medical Technology, EDO							
IML-1 (7 days)										△ Neurovestibular, Human Performance, Radiation, Cell Biology, Plant Biology, EDO						
SL-J (7 days)										△ Cardiovascular Countermeasures, Gravitational Biology						
SL-D2 (10 days)											△ Cardiovascular/Fluids					
SLS-2* (13 days)											△ Cardiovascular, Metabolic, Musculo-skeletal, Neurovestibular, EDO					
IML-2 (13 days)												△ Performance, Space Biology, EDO				
SL-E1 (16 days)													△ (Squirrel Monkey RAHF)			
SLS-3* (16 days)														△ (Rhesus Facilty), Musculoskeletal		
SL-E2															(Squirrel Monkey RAHF) △	
SLS-4*																(Rhesus Facility) △

*Life Sciences Dedicated Missions

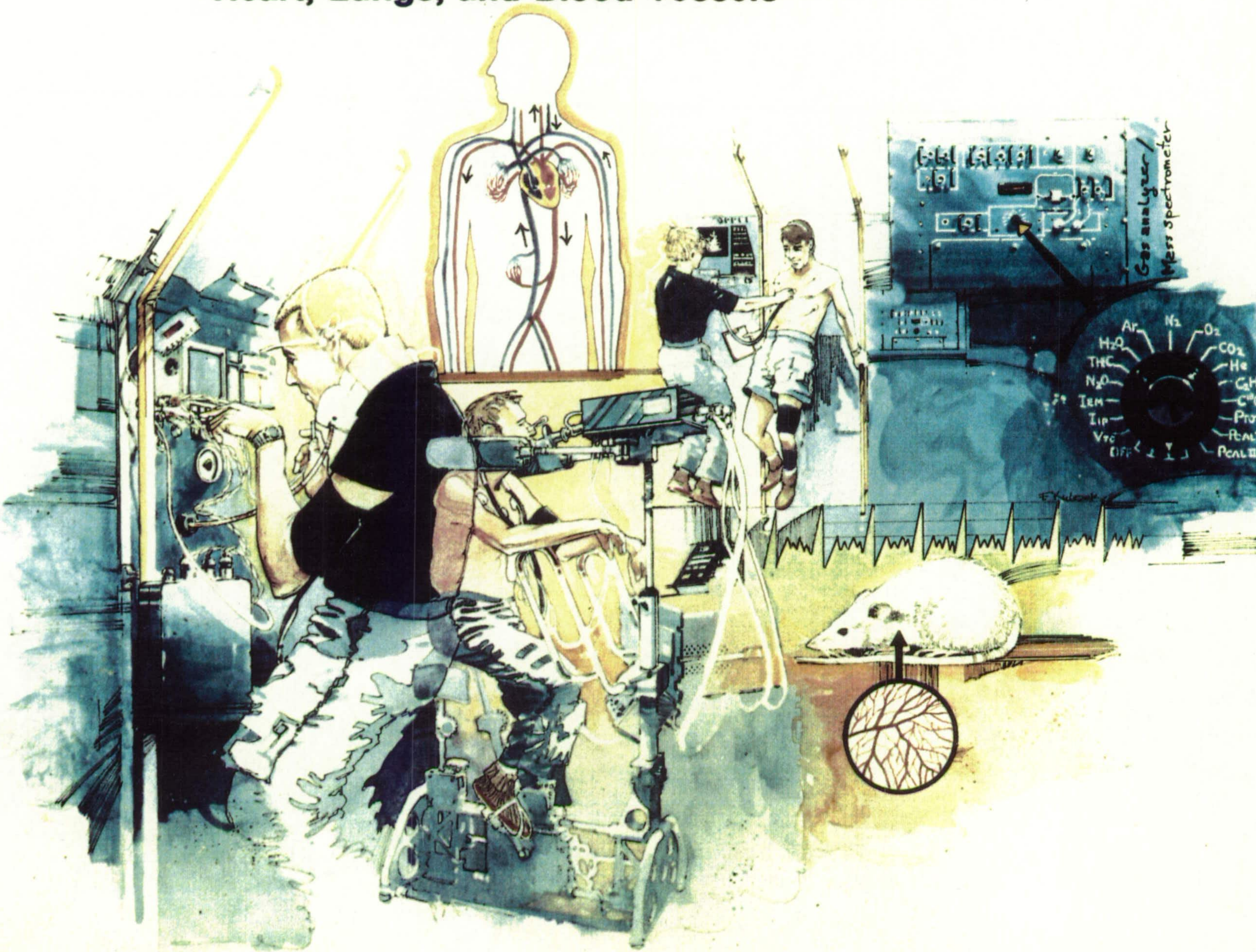
SLS - Spacelab Life Sciences
IML - International Microgravity Laboratory
SL-J - Spacelab - Japanese
SL-D2 - Spacelab - Deutsch
SL-E - Spacelab - European
EDO - Extended Duration Orbiter
RAHF - Research Animal Holding Facility

Space Effects on the Cardiovascular/Cardiopulmonary Systems

During space flight, the cardiovascular and the cardiopulmunary systems change their operation. Scientists have hypothesized that both systems begin to adapt to weightlessness when blood and other body fluids move from the feet, legs, and lower trunk to the upper body, the upper trunk, and the head. Presumably, this **fluid shift** occurs in part because gravity is no longer present to help pull the fluids to the lower part of the body. In space, as the fluids redistribute, the body detects a "flood" in its upper regions and then reacts to correct this situation by getting rid of some of the "excess" body fluids. Evidence has shown that the new lower volume of blood and other fluids causes the heart to reduce in size (it does not have to work so hard), causes a small increase in resting heart rate, and a slight decrease in performance during exercise.

While some detailed studies of the cardiovascular system have been made, thorough studies of the lungs, which are very sensitive to gravity, have yet to be made in weightlessness. On Earth, gravity causes ventilation, blood flow, gas exchange, and pressure to vary in different regions of the lungs; scientists want to measure these parameters in microgravity to determine what changes may occur. During space flight, astronauts have described small decreases in lung capacity; scientists speculate that these may be related to increases in blood volume in the upper body, but more precise measurements are needed to verify this hypothesis.

The Cardiovascular/Cardiopulmonary System: Heart, Lungs, and Blood Vessels



SLS-1 Studies of the Cardiovascular/Cardiopulmonary Systems

The SLS-1 experiments designed to characterize cardiovascular function are the first to measure the cardiovascular effects of fluid redistribution and the resulting adaptation over the course of an entire Shuttle mission. The mission will also be the first opportunity to assess in a comprehensive way the effects of space flight on human pulmonary function. The following are the critical questions that will be addressed by the four interrelated SLS-1 studies listed below.

- How do the heart, lungs, and circulatory system adjust to microgravity and respond to exercise stress during space flight?
- What are the factors leading to the difficulties that astronauts experience when standing immediately after landing the Shuttle back on Earth (known as orthostatic intolerance)?
- What are the factors leading to impaired exercise performance that astronauts experience upon return to Earth?

SPACELAB LIFE SCIENCES 1 PRIMARY PAYLOAD

CARDIOVASCULAR/CARDIOPULMONARY

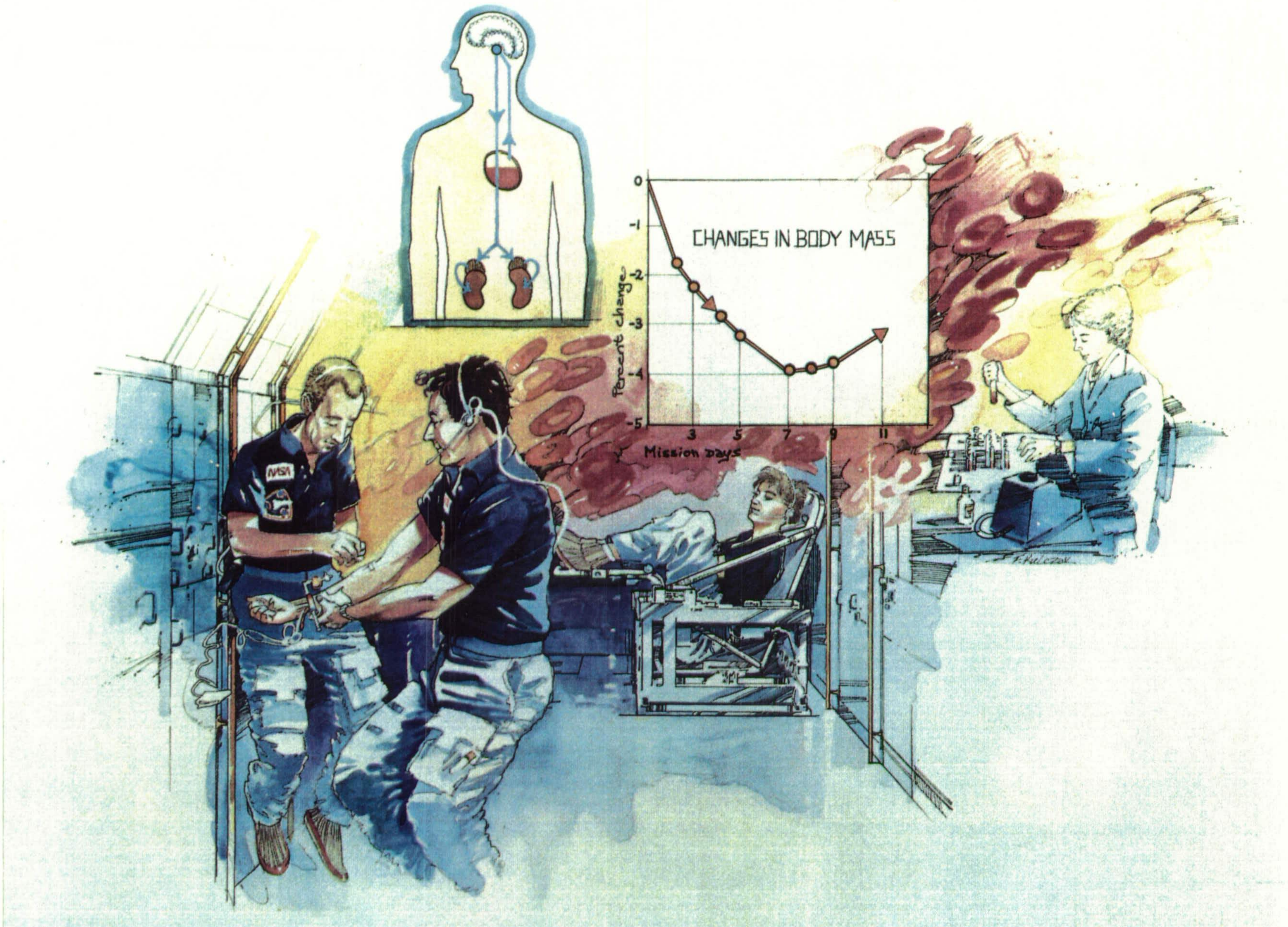
EXPT. NO.	INVESTIGATOR AND INSTITUTION	EXPERIMENT TITLE	SPECIES
294	C. G. Blomqvist University of Texas	Cardiovascular Adaptation to Zero-Gravity	Human
066	L. E. Farhi State University of NY	Inflight Study of Cardiovascular Deconditioning	Human
022	D. L. Eckberg Medicine College of Virginia	Influence of Weightlessness Upon Cardiovascular Control	Human
198	J. B. West University of California	Pulmonary Function During Weightlessness	Human

Space Effects on Blood and Fluid Regulation

Just as a thermostat keeps a room at a set temperature, the kidneys and hormones help to maintain the stability of the body by regulating the amount of fluids and electrolytes (dissolved salts and minerals in the fluids of the body). One of the main functions of the kidneys and hormones is to regulate blood and other fluid volumes. Studies related to assessing kidney and hormone function in space suggest that as microgravity causes fluid to migrate toward the head, the upper part of the body perceives an apparent increase in blood volume; the kidneys and hormones react by removing fluids (such as blood plasma) and electrolytes. This results in an increased proportion of solids in the blood, such as red blood cells (RBCs) and white blood cells (i.e., lymphocytes, which are related to the body's ability to fight infections). Then the body may try to reduce what it perceives as too many RBCs and lymphocytes.

Space flight studies have, in fact, shown a decrease in the circulating volume of both RBCs and lymphocytes. A decrease in RBCs may impair a crew member's ability to function with full efficiency upon return to Earth. In addition, although astronauts have shown no increased susceptibility to disease after flight, a decrease in the number of circulating lymphocytes may affect a crew member's ability to resist infections during long-duration space missions. Important space studies aimed at more clearly understanding the mechanisms related to fluid regulation and the resulting effects on RBCs and lymphocytes are essential to the characterization of the potential risks associated with these changes, and the development of effective countermeasures.

The Blood and Fluid Regulation Systems: Kidneys, Electrolytes, and Blood Cells



SLS-1 Studies of Blood and Fluid Regulation

SLS-1 hematology experiments study two parts of the blood system: the liquid plasma portion, which contains water, proteins, nutrients, electrolytes, hormones, and metabolic wastes; and the cellular portion, which includes red blood cells. The immunology experiment will study the changes in circulating lymphocyte function. To effectively tie these phenomena together, an extensive study related to the kidney's regulation of fluid will be carried out on the mission. The following critical questions will be addressed through the five interrelated investigations listed below.

- What are the factors influencing red blood cell production and destruction during space flight and how are they implicated in the observed loss of red cell mass?
- What role do the kidneys and hormones have in regulating body fluid and electrolyte loss and redistribution during space flight?
- Is lymphocyte function altered by microgravity and does this impair the immune system?

SPACELAB LIFE SCIENCES 1 PRIMARY PAYLOAD

BLOOD AND FLUID REGULATION

EXPT. NO.	INVESTIGATOR AND INSTITUTION	EXPERIMENT TITLE	SPECIES
Renal-Endocrine 192	C. Leach Johnson Space Center	Fluid-Electrolyte Regulation During Space Flight	Human
Hematology 261	C. P. Alfrey Baylor College of Med.	Influence of Space Flight on Erythrokinetics in Man	Human
141	C. P. Alfrey Baylor College of Med.	Regulation of Blood Volume During Space Flight	Rat
012	R. D. Lange Univ. of Tennessee	Regulation of Erythropoiesis During Space Flight	Rat
Immunology 240	A. Cogoli Swiss Fed. Inst. of Tech.	Lymphocyte Proliferation in Weightlessness	Human

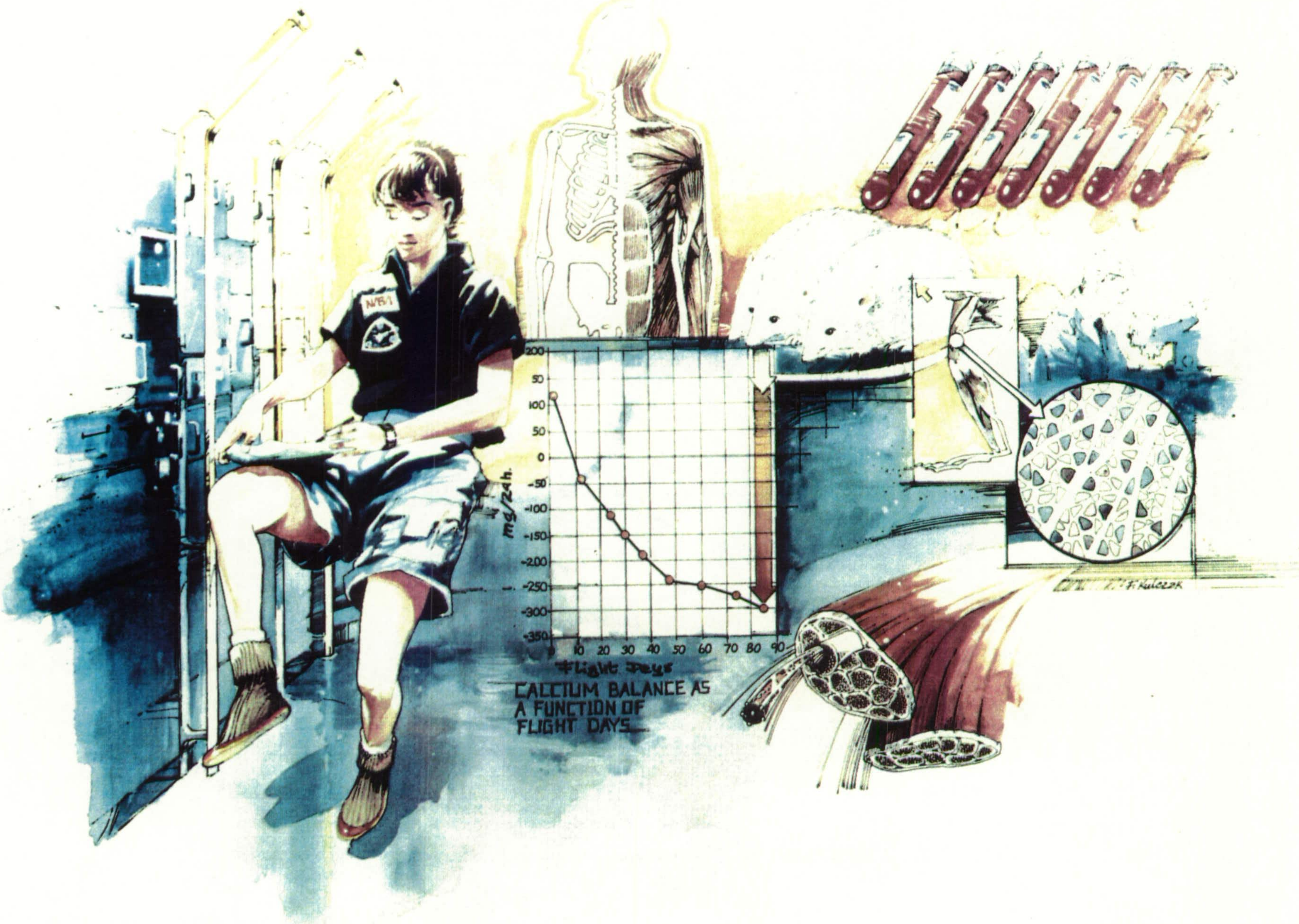
Space Effects on the Musculoskeletal System

Gravity shaped the architecture of the human body - its more than 600 muscles and 200 bones. Consequently, the musculoskeletal system requires gravity to function normally. Without gravity, muscles waste away, and bones become smaller and weaker. Doctors have observed these effects in bed rest patients whose movement and exercise have been curtailed; to a degree, the same effects have also been observed in space flight crews.

In microgravity, leg muscles often become weakened from lack of use because astronauts can "float" instead of walk. Specific changes include a loss of nitrogen from the muscle, loss of lower body mass, reduced muscle mass in the calves, and decreased muscle strength. Weightlessness also causes a slow loss of bone minerals (calcium and phosphorus). Crew members from previous flights have shown a negative calcium balance throughout the missions. Most of the loss is thought to occur in the leg bones and the spine, which are responsible for erect posture and locomotion.

An understanding of the time course and extent of muscle and bone alterations is critical to determining how long humans may safely remain in space and what can be done to halt negative effects. In addition, the development of effective measures to counter the loss of bone in space may contribute to improved therapy or management of osteoporosis, which is characterized by gradually decreasing bone mass and strength and is the most prevalent clinical bone disorder on Earth.

The Musculoskeletal System: Muscles and Bones



SLS-1 Studies of the Musculoskeletal System

Six SLS-1 experiments study the mechanisms responsible for muscle and bone loss in humans and rats. These experiments will further determine which muscles are affected and what biochemical mechanisms are responsible for altering the nitrogen balance of muscles and the calcium balance of bones. The following are the critical questions that will be addressed through the SLS-1 experiments listed below.

- What early physiological events are involved in the muscle atrophy of space flight?
- What are the early factors of significance in the demineralization of bone during space flight?

SPACELAB LIFE SCIENCES 1 PRIMARY PAYLOAD

MUSCULOSKELETAL

EXPT. NO.	INVESTIGATOR AND INSTITUTION	EXPERIMENT TITLE	SPECIES
Muscle 120	T. P. Stein University of Medicine & Dentistry of New Jersey	Protein Metabolism During Space Flight	Human
127	K. M. Baldwin University of California	Effect of Zero-Gravity Exposure on Biochemical and Metabolic Properties of Skeletal Muscle	Rat
247	J. F. Y. Hoh University of Sydney	Skeletal Myosin Isoenzymes in Rats Exposed to Zero-Gravity	Rat
303	D. A. Riley Medical College of Wisconsin	Electron Microscopy, Electromyography and Protease Activities of Rat Hind Limb Muscles	Rat
Skeleton 305	C. Arnaud University of California	Pathophysiology of Mineral Loss in Space Flight	Human
194	E. Morey-Holton Ames Research Center	Bone, Calcium and Space Flight	Rat

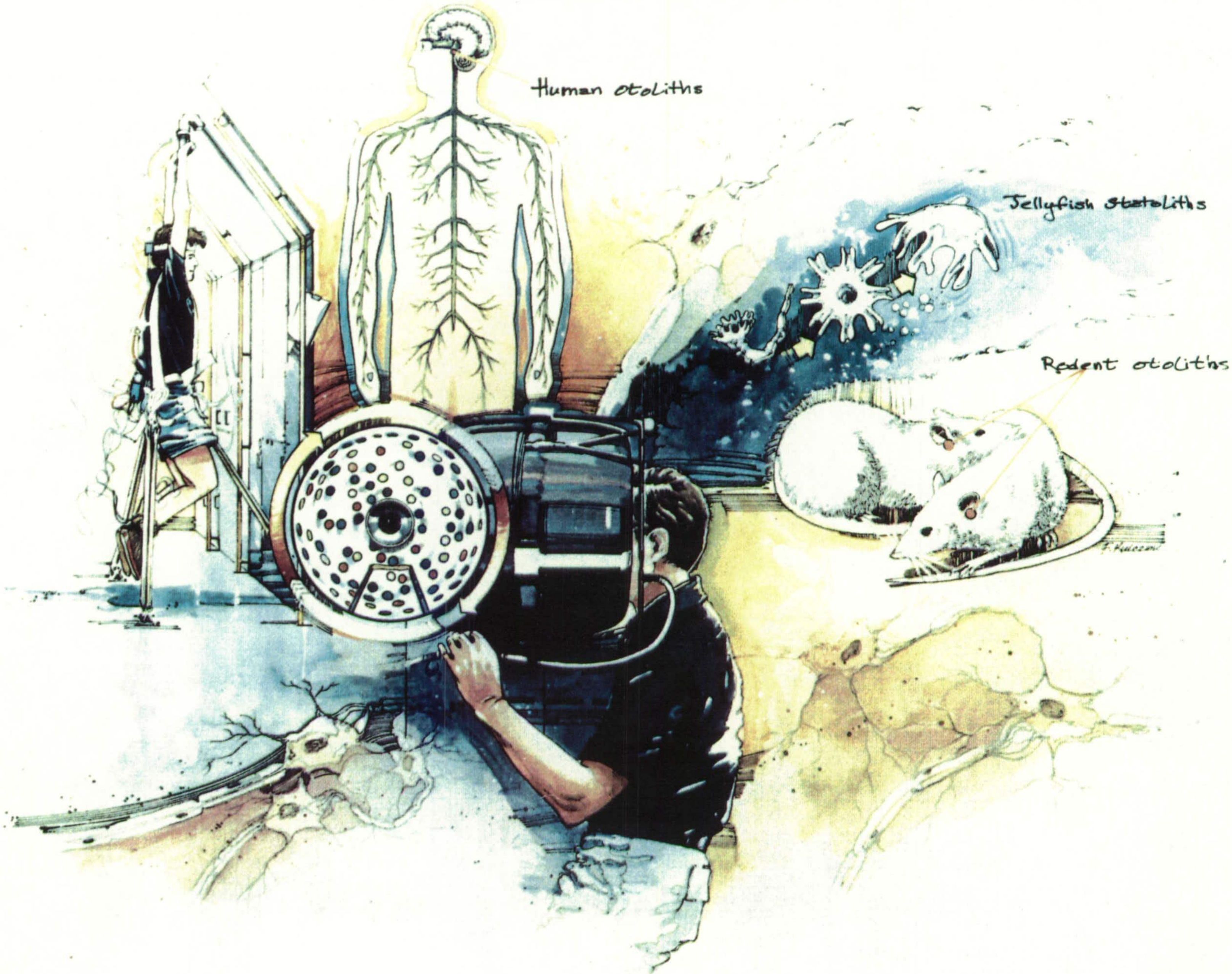
Space Effects on the Neurovestibular System

The neurovestibular system, which helps people orient their bodies, is very sensitive to gravity. For instance, the otoliths, small vestibular organs in the inner ear, respond to the acceleration of an elevator. As a person changes positions, gravity pulls tiny clumps of crystals down and bends hairs in the inner ear; then, signals from the more than 20,000 nerve cells in each ear tell the brain the head's position. Nerves also constantly perceive gravity as muscles relax and contract and use this information to sense body position. The eyes see surroundings and sense the body's relationship to other objects. The combined sensory input from the inner ear, the nerves, and the eyes help orient the brain to stay aware of the body's position relative to the force of gravity.

In space, gravity no longer tugs at the otolith crystals, and the muscles no longer have to support the weight of the limbs. Theory suggests that, in microgravity, information sent to the brain from the inner ear and other sensory organs conflicts with visual information and all of the other cues anticipated from past experience in Earth's gravity environment. This conflict results in disorientation.

Neurosensory research in space has focused on space motion sickness because changes in neurovestibular activity may cause this ailment, which has affected about one-half of all space travelers. Although astronauts have used some drugs successfully to reduce nausea, no treatment eliminates the symptoms. Experiments have focused on identifying the underlying causes of this problem, on determining ways to treat it, and on studying how the nervous system adapts to microgravity.

The Neurovestibular System: Brain and Nerves, Eyes and Inner Ear



SLS-1 Studies of the Neurovestibular System

A comprehensive investigation using humans will study how the entire sensory system adapts to weightlessness. Scientists will study space motion sickness, posture control, and human spatial orientation as well as the interrelated functioning of the inner ear, the eyes and the reflexes. Other SLS-1 experiments with rodents and jellyfish examine the structure of gravity sensitive organs to see if weightlessness causes any anatomical changes to vestibular organs, particularly the otoliths (rodents) or statoliths (jellyfish). The following are the critical questions that will be addressed through the SLS-1 experiments listed below.

- Is there a relationship among space motion sickness and other measured physiological and behavioral variables?
- How does microgravity affect the neurosensory control of posture, spatial orientation and eye tracking?
- Does the loss of gravity stimulation alter the tissue characteristics of the gravity sensing organs?

SPACELAB LIFE SCIENCES 1 PRIMARY PAYLOAD

NEUROSCIENCE

EXPT. NO.	INVESTIGATOR AND INSTITUTION	EXPERIMENT TITLE	SPECIES
072	L. Young Mass. Institute of Tech.	Vestibular Experiments in Spacelab	Human
238	M. Ross Ames Research Center	A Study of the Effects of Space Travel on Mammalian Gravity Receptors	Rat
DCL	D. B. Spangenberg Eastern Virginia Medicine School	Effects of Microgravity-Induced Weightlessness on Aurelila Ephyra Differentiation and Statolith Synthesis	Jellyfish

SLS-1: A Mission of Firsts

What makes the SLS-1 mission unique?

- It is the first Spacelab dedicated to life sciences research.
- It is the first pressurized Spacelab dedicated to a single discipline.
- It is the first American mission in which comprehensive experiments will use a multi-species (human, rat, jellyfish), multi-disciplinary approach to study the physiological adaptation to microgravity.
- It is the first flight to include so many doctorate level crew members: two Ph.D.'s and three M.D.'s.
- It is the first mission to fly three female crew members at one time (the most ever flown on one mission). This will substantially increase the amount of much-needed physiological data collected from females.

SLS-1 will also generate a number of specific scientific firsts.

- It is the first mission to:

  measure kidney function directly
  study maximum exercise in a systematic manner
  measure barorecepter reflex (blood pressure control) response in flight
  make comprehensive pulmonary (lung) measurements
  measure cardiac output and body fluid volumes in flight
  use the jellyfish as a model to study neurovestibular changes
  use tracers (chemicals used to track specific metabolic processes) to monitor the physiological responses that occur in microgravity


Jellyfish statoliths
Rodent otoliths

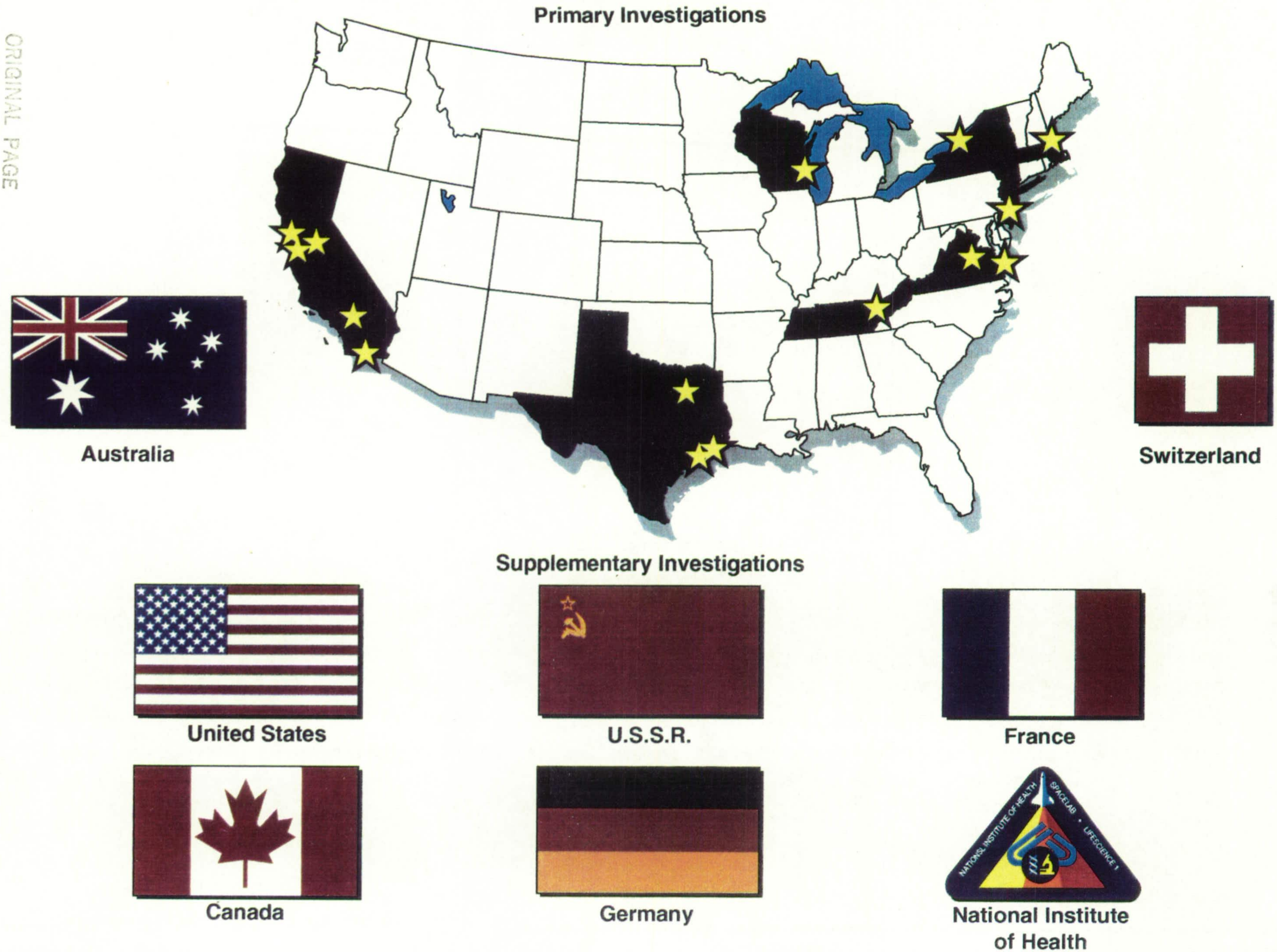
International/Interagency Aspects of SLS-1

The SLS-1 mission has both international and interagency participation. While the 18 primary investigations are all sponsored by NASA, the primary payload includes one principal investigator from Switzerland and one from Australia.

In addition to the primary payload, which is the basis of the mission, a number of supplementary investigations will be conducted with international participation under what is known as the Biospecimen Sharing Plan. The plan calls for space-flown rodent tissues left over from designated primary investigations to be distributed postflight to scientists from the U.S.S.R., France, Germany, and Canada. The involvement of these foreign scientists will help to maximize the science return from the SLS-1 mission.

The National Institutes of Health (NIH) is also participating in the Biospecimen Sharing Plan for SLS-1. This will be the first occasion where the two agencies, NASA and NIH, have cooperated to maximize the science return from a Space Shuttle mission. Discussions underway between the agencies are focusing on potential areas for cooperation in the future.

SLS-1 INSTITUTIONAL AND INTERNATIONAL PARTICIPATION



Detailed Supplementary Objectives (DSOs) Onboard SLS-1

Detailed Supplementary Objectives (DSOs) are operationally related studies designed to gather crucial information that can only be obtained during and immediately following space flight. Most of the DSOs on SLS-1 support NASA's Extended Duration Orbiter Medical Program, which is designed to develop an appropriate set of countermeasures to enable Shuttle crews to remain in space for up to 16 days. The DSOs on SLS-1 have been carefully selected to complement the primary investigations and to enhance the overall return from the mission. The DSOs that will be performed on SLS-1 are shown in the chart below.

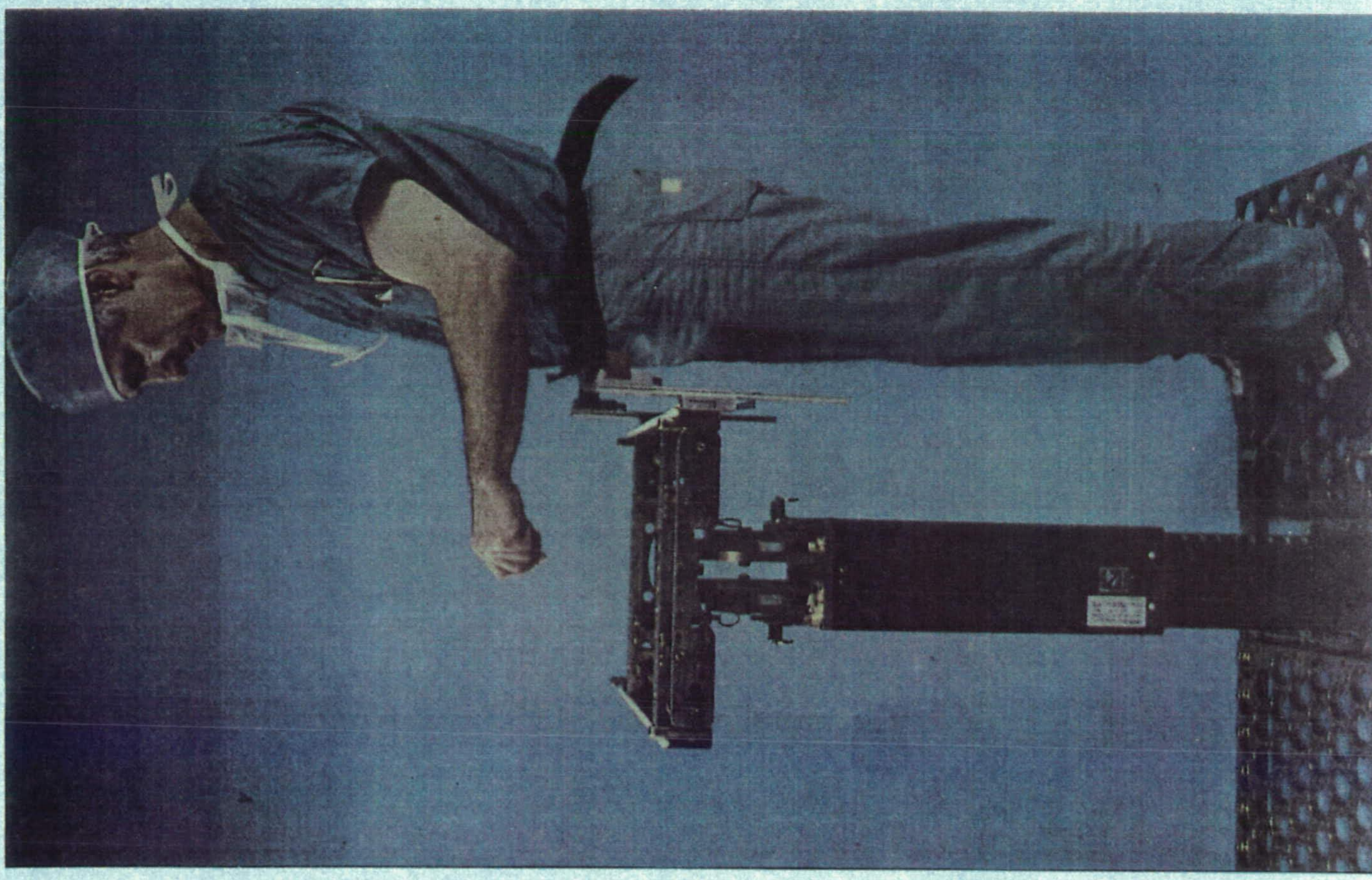
Detailed Supplementary Objectives (DSOs)

Tissue Equivalent Proportional Counter (TEPC)	Establish, evaluate, and verify analytical and measurement methods for assessing and managing health risks from exposure to space radiation.
Inflight Aerobic Exercise	Document effects of daily aerobic treadmill exercise on protection of left ventricular dimensions and postflight orthostatic function.
Baroreflex (SLS-2 Protocol)	Determine the relationship between carotid sinus baroreceptor dysfunction and flight duration (blood pressure receptors in the neck).
Postural Stability	Quantify effects that in-flight neurosensory adaptations to zero-g have on postflight control of postural equilibrium.
Magnetic Resonance Imaging (MRI)	Quantitate by noninvasive technique changes in leg muscle strength and dimensions, and water or lipid content changes.
Microbial Air Sampler (MAS), Archival Organics Sampler (AOS)	Collect data on spacecraft contaminant levels on missions of varying durations to establish baseline levels and to evaluate potential risks to crew health and safety.
Assessment of Human Factors	Assess human factors concerns including acoustic noise, stowage issues, interference from cables and wiring, adequacy of foot restraints and handholds, plus evaluation of timeline accuracy for experiment performance.
Spacelab/Orbiter-Debris/Contamination Study	A comprehensive analysis of the spacelab/orbiter atmosphere will be performed which includes particulates in the respirable range, organic and inorganic volatiles, airborne and surface microbial contamination, and debris collected from the spacelab and orbiter filters.

Special Hardware Verification Tests Onboard SLS-1

The primary SLS-1 experiments investigate the biology of humans and other animals in space, but some secondary studies are included to gather data that complement the major investigations or to develop space facilities for future missions. For example, certain instrument operations and experiment protocols on SLS-1 will influence the design of two pieces of medical equipment that are to be incorporated into the Health Maintenance Facility for Space Station Freedom: the Surgical Work Station (shown below), and the Intravenous Fluid Pump.

The SLS-1 crew members will evaluate the effectiveness and convenience of the restraining features of the Surgical Work Station (shown below), a surgical table and restraining system (which includes a restraint surface for the patient, a restraining belt for the medical officer, and a table for instruments and equipment) developed to facilitate certain surgical procedures that may be necessary aboard Space Station Freedom. The second instrument to be evaluated is a pump for intravenous infusions. Many medical techniques involving fluid transfers, such as intravenous procedures, make use of Earth's gravity in their operations, but because fluids behave differently in space than on Earth, it is critical to develop instruments that transfer fluids effectively in microgravity.



Materials Sciences and Other Small Studies Aboard SLS-1

The following are some activities not sponsored by the NASA Life Sciences Division, which will also be flown on SLS-1.

Materials Sciences Experiments: The NASA Microgravity Sciences Division is sponsoring two materials sciences experiments. The Solid Surface Combustion Experiment will study how flames produced by solid fuels behave in microgravity. The data obtained will contribute to crew and payload safety. The Space Acceleration Measurement System (SAMS) is designed to make highly sensitive measurements of the vibrational characteristics of work being done in the Shuttle. This data will complement the biological measurements obtained in the life sciences experiments.

Get Away Specials (GAS): The Get Away Special (GAS) Program is a program provided by NASA to allow private and public sponsorship of small experiments to be flown on the Space Shuttle on a modest-cost, space-available basis. The following Get Away Specials are being flown on SLS-1:

G-021	Solid State Microaccelerometer Experiment. European Space Agency
G-052	Crystal Growth. GTE Laboratories, Inc.
G-091	Ball Bearing Manufacture. CSUN Aerospace Group
G-105	Package of six experiments (four materials sciences, two cosmic ray experiments) co-sponsored by the Alabama Space and Rocket Center and NASA's Consortium for Materials Development in Space at the University of Alabama
G-286	Foamed Metal Samples Production. OMNI Publications International, Ltd.
G-405	Precipitates in Zero Gravity Experiment. Frontiers of Science Foundation
G-408	Package of five experiments (materials sciences, life support, and radiation) co-sponsored by the MITRE Corporation and Worcester Polytechnic Institute
G-451	Effects of Weightlessness on Flower and Vegetable Seeds. NISSHO IWAI American Corporation
G-455	Growth Mechanism of Semiconductor Single Crystals. NISSHO IWAI American Corporation
G-486	Package of four soldering and four desoldering experiments sponsored by EDSYN, Inc.
G-507	Orbiter Stability Experiment. Goddard Space Flight Center
G-616	Two experiments (radiation, plant biology) sponsored by Thomas Hancock

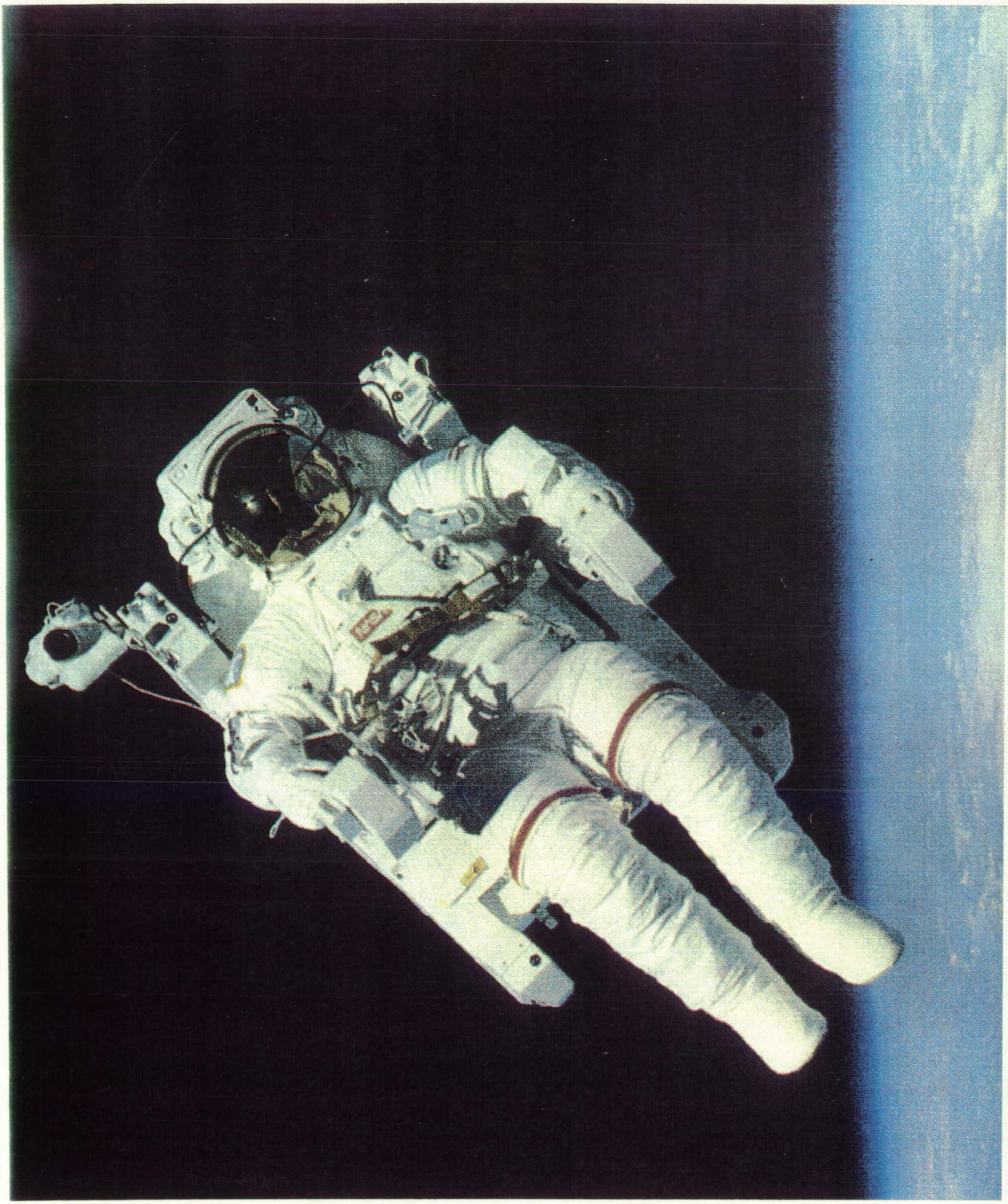

SMALL SELF-CONTAINED PAYLOADS
GET AWAY SPECIAL
NASA

SLS-1 Educational Activities

The SLS-1 Mission has inspired the development of a number of educational activities directed at helping teachers more effectively communicate the excitement of science in the classroom. The key to stimulating students to consider science as a potential career choice (an important U.S. educational goal) is the ability to spark students' interest in science at the primary and secondary school levels. The new SLS-1-related materials present science topics that use the subject of space to capture the student's imagination and stimulate critical thinking through a hands-on approach that allows for direct student interaction with the important science concepts.

"Human Physiology in Space: A Program for America" has been designed as a supplement to the secondary school science curriculum. The package acquaints teachers and students with rudiments of physiology in space, and presents classroom exercises and laboratory experiments based on the SLS-1 experiments. The materials have already been used and evaluated by 80 teachers and almost 7000 high school students; an additional 40 teachers and about 2000 high school students are now using the supplement in the second phase of this pilot project. Preliminary results from the evaluation show this supplemental program to be highly effective in stimulating students' interest in physiology, science, and space.

Students at these levels are excited by the space program, which synthesizes science and engineering, and offers startling visual images. A special video will be created from in-flight footage filmed during the SLS-1 Mission. The video, which will be available soon after the flight of SLS-1, will provide teachers with a valuable supplement to the biology/physiology curriculum. The video will use the intrinsic excitement of space flight to familiarize students with the scientific method, and with important concepts, and current and future directions, in the life sciences.

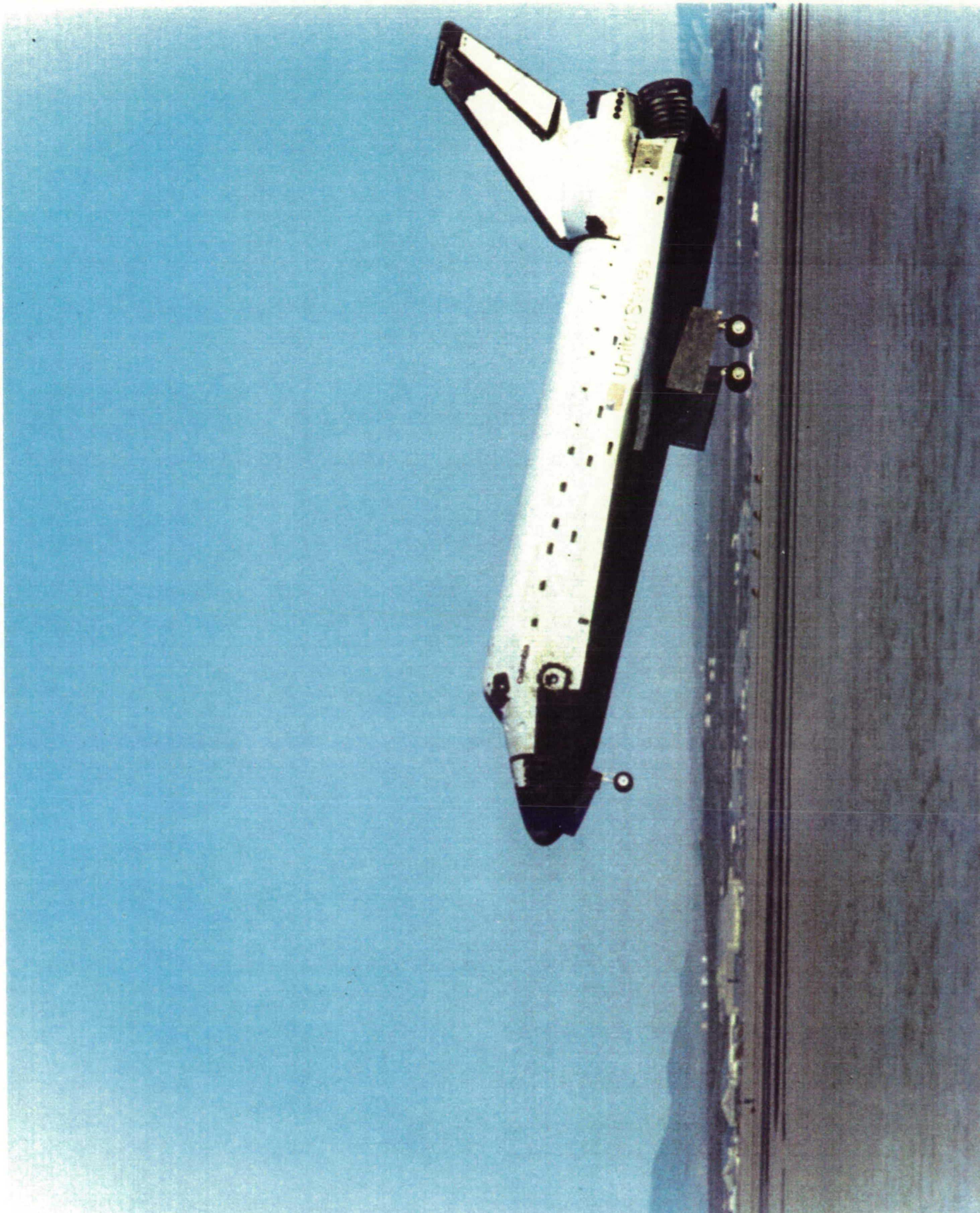


SLS-1 Crew Participation: Maximizing Science Return

The crew of the SLS-1 Mission will be extremely busy during each day of the mission. Most crews who fly aboard the Space Shuttle carry out a split-shift operation where half of the crew work while half sleep. SLS-1 follows a **single-shift operation** where all crew members follow the same work/sleep cycles. The mission timeline of activities is full and includes daily work cycles of about 10 hours in duration, sleep cycles of about 8 hours in duration, and a pre-sleep period and a post-sleep period (each about 2-3 hours) that the crew will use for personal time. The maintenance of a stable schedule is of extreme importance in order to preserve the normal rhythms of the body and minimize the disturbances that might affect the scientific physiological data that will be collected on the astronauts.

After 9 days in orbit, the crew will return to Earth. Once the orbiter has landed, two major activities will begin. First, the crew members will be loaded into a waiting "People Mover," a crew transfer vehicle that docks directly to the Space Shuttle and is equipped with biomedical monitoring equipment. Post-flight physiological measurements will be taken to augment the already collected pre-flight and in-flight measurements. In addition, the physical condition of the crew members will be evaluated. Post-flight studies on certain members of the crew will continue for 7 days in order to document the short-term adaptive responses of the astronauts upon return to Earth's gravity.

Second, the jellyfish and the rodents will be unloaded from the orbiter and taken to a post-flight analysis facility nearby. Science teams will be prepared to analyze the animals on-site. Analyses of all human and animal ground and flight data will occupy the SLS-1 scientists for months, and the results will then begin to flow into the life sciences community, to allow scientists a greater understanding of how the body functions both in space and here on Earth.


United States

STS-40 Aboard the Columbia Orbiter

SLS-1 will fly on the Space Shuttle Columbia. The Spacelab—a cylindrical space laboratory being used for SLS-1—is approximately the size of a bus, and is generally heavier than most other Space Shuttle payloads. This weight must be borne not only through launch, but through re-entry and return to Earth. Therefore, the SLS-1 mission will fly on the Space Shuttle orbiter Columbia, NASA's first orbiter, which is preferred for heavier payloads, due to its somewhat greater structural integrity. Columbia also has five cryogenic tank sets (versus three or four in the other orbiters); these extra tanks provide additional energy to enable missions of extended duration. The additional energy thus provided allows the mission to run at higher power over a longer-than-usual period of time, 9 days for SLS-1.

SLS-1 Mission Parameters

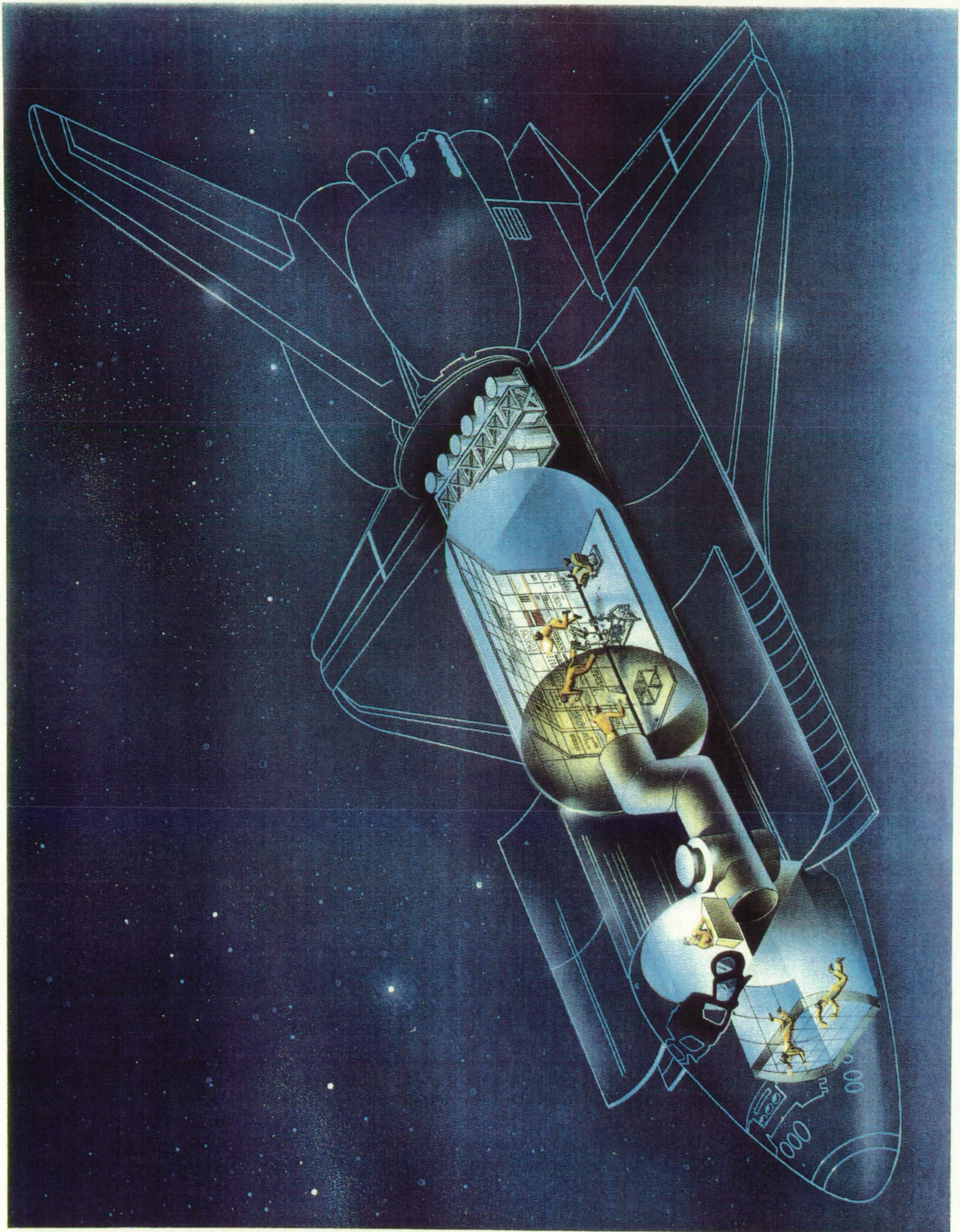
Launch Site:	Kennedy Space Center, FL
Shuttle Orbiter:	Columbia
Insertion Altitude:	160 nautical miles (184 statute miles)
Operational Altitude:	150 nautical miles (173 statute miles)
Orbital Inclination:	39 degrees
Mission Duration:	9 days
Prime Landing Site:	Edwards Air Force Base, CA
Alternate Landing Site:	Kennedy Space Center, FL


Columbia
United States
NASA

Spacelab

The Spacelab, developed by the European Space Agency (ESA) and flown on the U.S. Space Shuttle, is a reusable, modular laboratory carried in the Shuttle's payload bay. It is a cylindrical room that is 23 feet (7 meters) long and 16 feet (5 meters) wide, about the size of a bus. Experiments are performed in this enclosed, pressurized module, which contains the necessary utilities, computers, work areas, experiment hardware, and instrument racks. The crew move between the laboratory and the middeck living quarters through a tunnel connected to the Shuttle middeck. The flexibility of the modular design permits interchangeable Spacelab elements to be arranged in combinations that best suit mission needs, reduces the cost of space experimentation, and provides for the needs of a spectrum of scientific disciplines.

For SLS-1, NASA is outfitting Spacelab with instruments routinely found in biomedical research laboratories. Most SLS-1 scientists will use NASA Life Sciences Laboratory Equipment, an inventory of multi-purpose, reusable medical and biological instruments that have been developed or modified for use in microgravity. The equipment includes animal holding facilities, refrigerator/freezers, small and large mass measurement devices, exercise devices (bicycle ergometer and treadmill), and a special work station. These basic research instruments will be augmented by equipment designed specifically for particular investigations, such as cardiovascular and cardiopulmonary testing apparatus and cell incubators.



SLS-1 Spacelab Configuration

Port Racks

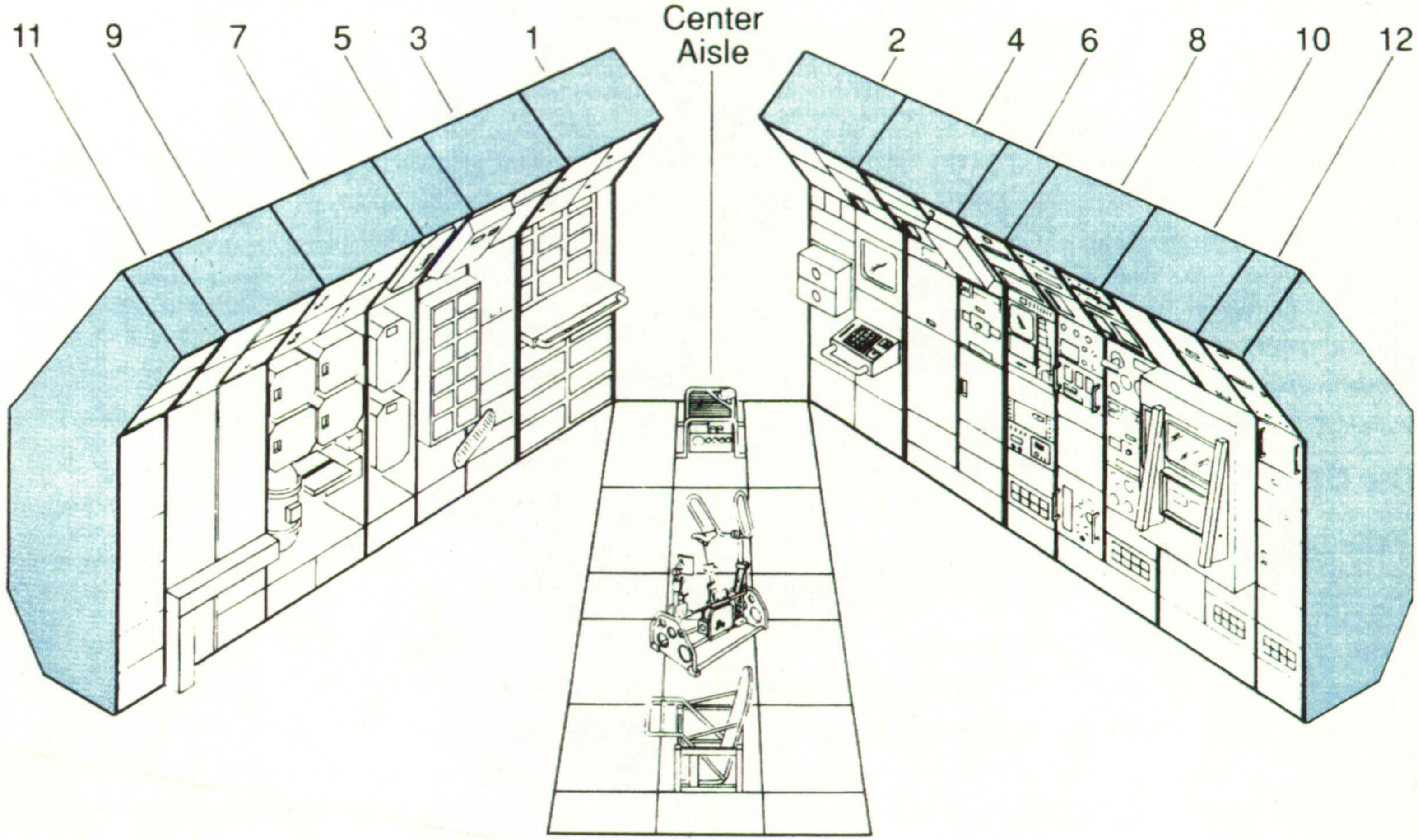
Rack 1: Workbench
Rack 3: Research Animal Holding Facility
Rack 5: SMIDEX single rack
Jellyfish experiment
Space Acceleration Measurement System
Rack 7: SMIDEX double rack
Solid Surface Combustion Experiment
Noninvasive Central Venous Pressure
Intravenous Infusion Pump
American Flight Echocardiograph
Surgical Workstation
Rack 9: Refrigerator/Freezers
Small Mass Measurement Instrument
Rack 11: Baroreflex Neck Pressure Chamber and electronics
Rotating Dome
Incubator
Low-g Centrifuge

Center Aisle

Body Restraint System
Bicycle Ergometer
Body Mass Measurement Device

Starboard Racks

Rack 2: Control Center
Rack 4: Television and video monitoring equipment
Spacelab support services
Gas Analyzer Mass Spectrometer
Rack 6: Echocardiograph
Experiment Command and Data System/ Microcomputer System
Rack 8: Gas Analyzer Mass Spectrometer
Rebreathing Assembly Unit
Life Sciences Laboratory Equipment (LSLE) Microcomputers
Vacuum Interface Assembly
Video Monitor
Cardiovascular/Cardiopulmonary Interface Panel
Cardiopulmonary Control Unit
Gas Tank Assembly
Rack 10: General Purpose Workstation
Rack 12: LSLE Centrifuge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12

The SLS-1 Crew Members

The crew of SLS-1 is shown in a group picture below. (Back row, left to right:) **Col. Bryan D. O'Connor** (USMC), Commander, holds an M.S. in aeronautical systems and a B.S. in engineering. He has served as the Assistant Shuttle Program Manager, as Chairman of NASA's Space Flight Safety Panel, and Deputy Director of Flight Crew Operations. SLS-1 is his second flight. **Dr. Tamara E. Jernigan**, Mission Specialist, received a Ph.D. in space physics and astronomy, holds an M.S. in engineering science, and a B.S. in physics. Her work at NASA Ames Research Center includes support of Shuttle flights from the Mission Control Center as Capsule Communicator. SLS-1 is her first flight. **Maj. Sidney M. Gutierrez** (USAF), Pilot, holds an M.A. in management and a B.S. in aeronautical engineering. Most recently he supported launch activities at Kennedy Space Center. SLS-1 is his first mission. (Front row, left to right:) **Dr. F. Andrew (Drew) Gaffney**, Flight Payload Specialist, holds an M.D., Fellowship in cardiology. He is an associate professor of medicine at the University of Texas Health Science Center in Dallas. Dr. Gaffney is a co-investigator on an SLS-1 cardiovascular experiment. **Dr. Millie Hughes-Fulford**, Payload Specialist, holds a doctorate in chemistry. She is a research chemist at the San Francisco Veterans Administration Hospital, where she is the Chief of the Laboratory for Cell Growth and Differentiation, and an associate professor of biochemistry in the Department of Medicine at the University of California in San Francisco. **Dr. M. Rhea Seddon**, Mission Specialist, holds an M.D. and a B.A. in physiology. At NASA, Dr. Seddon serves as Technical Assistant to the Director of Flight Crew Operations. She was a support crewmember for STS-6, and participated on Shuttle mission 51-D in 1985. SLS-1 is her second flight. **Dr. James P. Bagian**, Mission Specialist, has an M.D., is board certified in aerospace medicine, and holds a B.S. in mechanical engineering and works at NASA Johnson Space Center. On his first flight, STS-29, he helped deploy a major NASA communications satellite and performed scientific research. Not pictured is **Dr. Robert Ward Phillips**, Alternate Flight Payload Specialist. Dr. Phillips is a professor of physiology at Colorado State University. He holds a doctorate in veterinary medicine and a Ph.D. in physiology.


STS 40
O'CONNOR JERNIGAN GUTIERREZ
SEDDON GAFFNEY HUGHES-FULFORD BAGIAN
SPACELAB LIFE SCIENCES 1

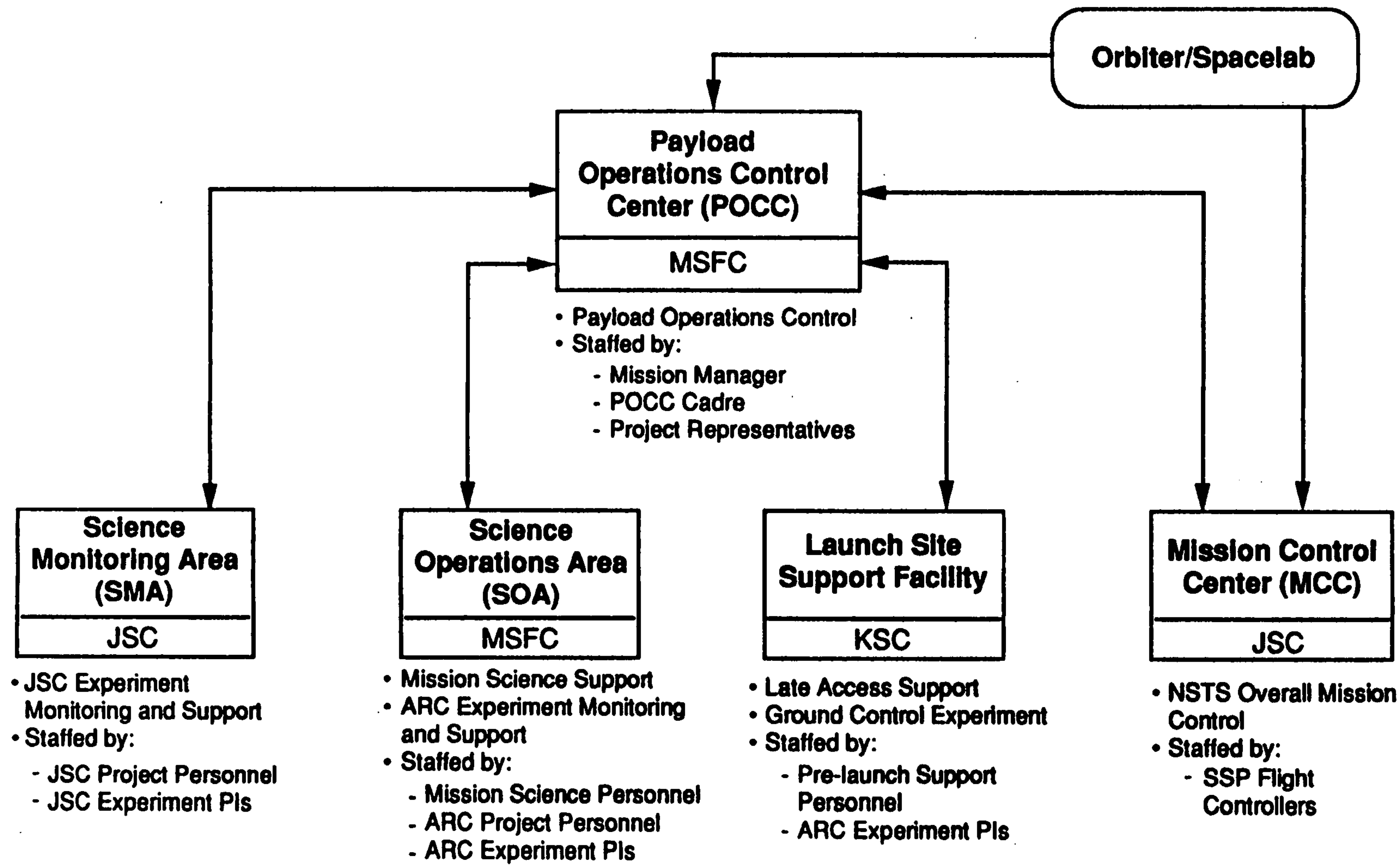
SLS-1 Ground Operations

Space Shuttle operations are directed from the Mission Control Center at NASA Johnson Space Center (JSC) in Houston, Texas. Throughout SLS-1, close contact will be maintained with the mission management team at the Payload Operations Control Center (POCC) at Marshall Space Flight Center in Huntsville, Alabama.

At the POCC in Huntsville, the SLS-1 ground team, including the Mission Manager, the Mission Scientist, and others, oversee Spacelab operations. The POCC will contain banks of television monitors, computers, and communications consoles. Responding to up to the minute information telemetered from the spacecraft, the team will re-plan as necessary, advise the crew, and work to solve any problems that arise. Each night a new shift will arive at the POCC to re-plan the next activities based on the previous day's accomplishments, while the crew sleeps.

Minute by minute, scientists will monitor their payload experiments from the ground, and, if necessary, troubleshoot or adjust experiment operations to increase scientific return. Some scientists will be based at the POCC, while others will work in the Science Monitoring Area at NASA's Johnson Space Center in Houston, Texas. Others support the mission from Kennedy Space Center and special life sciences facilities at Edwards Air Force Base, California. Both of these facilities are equipped to accommodate ground control experiments conducted simultaneously with flight experiments. Video and voice communications allow scientists on the ground to follow the progress of experiments in space. All scientific data are recorded.

POCC Interfaces

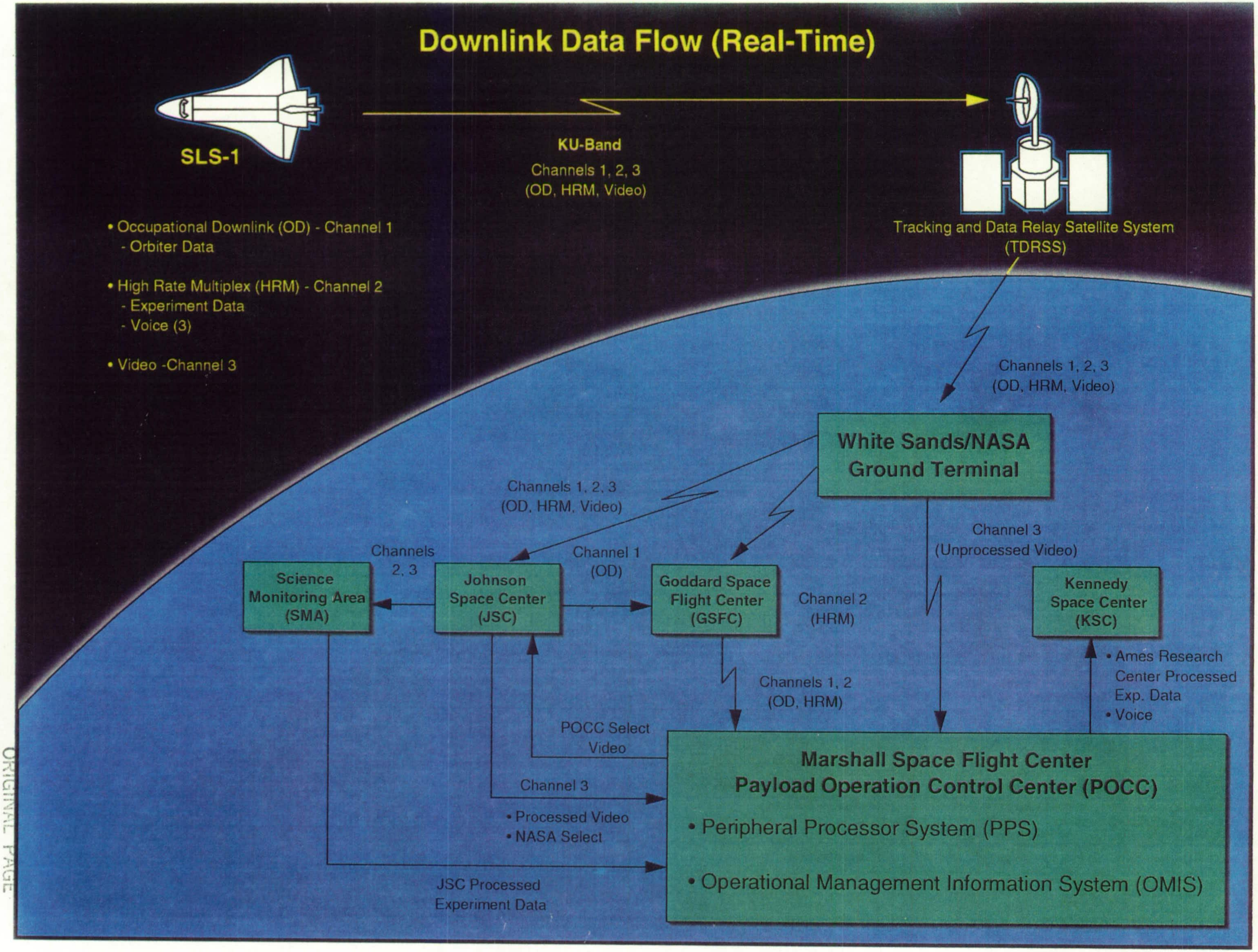


SLS-1 Data Transmission

Telemetry data from SLS-1 in-flight experiments will be downlinked via NASA's Tracking and Data Relay System Satellite (TDRSS) along three channels to NASA's White Sands Ground Station in White Sands, New Mexico. From White Sands, data will be re-directed to the Payload Operations Control Center (POCC) at Marshall Space Flight Center (Huntsville, Alabama). From the POCC, data will be distributed to the Test Monitoring Area (TMA) at Ames Research Center in Moffett Field, California, and to the Science Monitoring Area (SMA) at Johnson Space Center in Houston, Texas. Communications from the ground to space will also flow via White Sands and TDRSS.

Life sciences experiments are conducted in an interactive manner, sometimes requiring two-way feedback between the flight and ground crews. SLS-1 will involve constant real-time data transmission. The transmission will include digital, data, voice, and video for instrument and experiment monitoring. Science and auxiliary data will be put into telemetry packets onboard the spacecraft. Some data will be recorded and stored on the spacecraft, and "dumped" to the JSC SMA, where scientists will review experiment results at various intervals daily throughout the mission.

During the mission, scientists in the SMA will monitor their experiments, observing the displays, reports, graphs, and stripcharts that are produced from the real-time data stripped out of the downcoming stream. In parallel with older alpha-numeric displays, new workstations in the SMA will graphically display downlinked data, a capability that is being used for the first time with SLS-1. The stream will also be archived for later, more detailed analysis. The nature of the Space Shuttle mission is such that scientists will not be able to determine the results of their experiments until the data has undergone thorough analysis. All analysis will be done postflight by scientists in their home institutions. The data will later be incorporated in the Life Sciences Archive, for public dissemination and analysis.



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